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Level of Manganese and Copper in Selected Vegetables Marketed in Kaduna Metropolis

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ABSTRACT

Vegetables containing micronutrients such as manganese and copper are widely consumed due to their essential role in the human body. Human activities due to environmental pollution significantly contribute to high levels of manganese and copper in the human body, which can lead to toxic effects. The research is aimed at determining the level of manganese and copper in selected vegetables (*Lactuca sativa*, *Telfairia occidentalis*, *Vernonia amygdalina*, *Spinacia oleracea* and *Adansonia digitata*) marketed in Kaduna metropolis. The selected vegetables were processed and digested using a tri-acid mixture ($\text{HNO}_3:\text{HClO}_4:\text{H}_2\text{SO}_4 = 5:1:1$) and the Cu and Mn content of the digests obtained was determined by Atomic Absorption Spectrometry (AAS). The results obtained indicated that *Spinacia oleracea* had the highest (0.336 ± 0.001) level of Mn while *Telfairia occidentalis* had the least (0.018 ± 0.013). The highest (0.139 ± 0.0002) level of Cu was recorded in *Vernonia amygdalina* and the lowest level (0.068 ± 0.005) was found in *Lactuca sativa*. All the concentrations recorded are within the official WHO permissible limit of 5mg/kg for manganese and 4mg/kg for copper in vegetable plant materials. Therefore, these values may suggest that the selected vegetables are safe for human consumption.

Keywords: Copper; Manganese; Vegetables; Environment; Kaduna

1.0 INTRODUCTION

Heavy metals are natural components of the environment, but they are of concern because they are being added to water and edible vegetables in large amounts. This is due to the environmental pollution as a result of urbanisation and the expansion of industrial activities (Briffa *et al.*, 2020). Some heavy metals are essential elements to living organisms, while others have no beneficial role in the human body and their excessive amounts are generally harmful to plants and animals (Saikat *et al.*, 2022). Vegetables are diets taken by populations throughout the world, being sources of essential nutrients, antioxidants and metabolites. Green leafy vegetables increase the antioxidant capacity of the plasma through minerals, vitamins, and phytochemical compounds in their content and protect against oxidative stress which plays an important role in the pathogenesis of the cardiovascular disease (Shi *et al.*, 2022). Vegetables may contain a certain amount of heavy metals in high concentrations that can be toxic to the body and long-term consumption of these vegetables increases the possibility of tissue-organ damage. Many people develop kidney damage, cardiac disease, brain disorder

and liver problem as a result of consuming vegetables contaminated with a high concentration of heavy metals (Saikat *et al.*, 2022). These problems arise as a result of the lack of heavy metal assessment of these vegetables. Heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important components of human diet. Vegetables are rich sources of vitamins, minerals, and fibers, and also have beneficial anti-oxidative effects. However, intake of heavy metal-contamination of food items is one of the most important aspects of food quality assurance (Liang, *et al.*, 2019).

Rapid and unorganized urban and industrial developments have contaminated and contributed to the elevated levels of heavy metal in the urban environment of developing countries such as Egypt (Issa, *et al.*, 2018, Sara *et al.*, 2020).

Emission of heavy metals from industries and vehicles may be deposited on vegetable surfaces during their production, transport and marketing. Recently, (Al Amin, *et al.*, 2020) reported that atmospheric deposition can significantly elevate the levels of heavy metals contamination in vegetables commonly sold in the markets of

Varanasi, India. The prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (Klein-Junior et al., 2020). The present study aimed at assessing the level of manganese and copper in selected vegetables marketed in the Kaduna metropolis.

2.0 MATERIALS AND METHODS

2.1 Sampling

The vegetables: *Lactuca Sativa*, *Telfairia occidentalis*, *Vernonia amygdalina*, *Spinacia Oleracea* and *Adansonia Digitata* were purchased in Kaduna metropolis market. The five samples were identified at herbarium of Department of Pharmacognosy and Drug Development, Kaduna State University and voucher numbers of KASU/PCG/HERB/068, KASU/PCG/HERB/098, KASU/PCG/HERB/099, KASU/PCG/HERB/100 and KASU/PCG/HERB/101 were assigned respectively for the five samples. All the samples were thoroughly washed several times with running tap water, followed by distilled water and finally air dried and powdered.

2.2 Reagents and equipment

All experiments were performed with analytical reagent chemicals obtained from the British Drug House (BDH) Poole. De-ionized distilled water was used in preparing solutions. Stock solution of Pb was prepared by dissolving 1.598 g of Pb

(NO₃)₂ in 100 ml of deionized water. 5 ml of HNO₃ was added and the solution was transferred into a 1000 ml volumetric flask and made up to mark with distilled deionized water. Electronic weighing balance (Metlers Pr 63 Switzerland), porcelain pestle and mortar, muffle furnace (SXL, Searchtech), Gallen Kamp hot air oven (Philip Harries Ltd, England), Atomic Absorption Spectrophotometer (Agilent technologies 4200, Germany), Different sizes of beakers (Pyrex, England), conical flasks (Pyrex, England), funnel and measuring cylinders (Pyrex, England)

2.3 Sample Preparation and Analysis

Samples were prepared in three replicates using a wet digestion method (Horwitz, 1970). 1g of each of the dried leaf samples were weighed into an Erlenmeyer flask and digested with a tri-acid mixture (HNO₃:HClO₄:H₂SO₄ = 5:1:1) on a hot plate at 110 °C until dense white fumes appeared. The flask was allowed to cool, 40 mL of deionized water was then added and digestion continued until a clear solution was formed. The solution was cooled and filtered into a 100 mL volumetric flask and made up the volume to 50 mL with deionized water (Garba *et al.*, 2010). The digests obtained were used for the determination of Cu and Mn with an Atomic Absorption spectrophotometer (AAS).

2.4 Statistical Analysis

The results obtained are expressed as mean ± SD analysed using one-way analysis of variance (ANOVA) on SPSS 20.0 statistical software.

3.0 RESULTS

The concentrations ± (mg/kg) of copper and manganese of selected vegetables are in Tables 1 and 2.

Table 1: Concentration of copper in the selected five vegetables marketed in the Kaduna metropolis

Samples	Mean concentration ± SD (mg/kg)
<i>Lactuca sativa</i>	0.068 ±0.005
<i>Telfairia occidentalis</i>	0.089 ±0.0012
<i>Spinacia oleracea</i>	0.128 ±0.0002
<i>Vernonia amygdalina</i>	0.139 ±0.0002
<i>Adansonia digitata</i>	0.120 ±0.0005

Official permissible limit by WHO for copper is 4mg/kg

Table 2: Concentration of manganese in the five selected vegetables marketed in Kaduna metropolis

Samples	Mean concentration \pm SD	(mg/kg)
<i>Lactuca sativa</i>	0.102 \pm 0.002	
<i>Telfairia occidentalis</i>	0.018 \pm 0.013	
<i>Spinacia oleracea</i>	0.336 \pm 0.001	
<i>Vernonia amygdalina</i>	0.064 \pm 0.003	
<i>Adansonia digitata</i>	0.323 \pm 0.002	

Official permissible limit by WHO for manganese is 5mg/kg

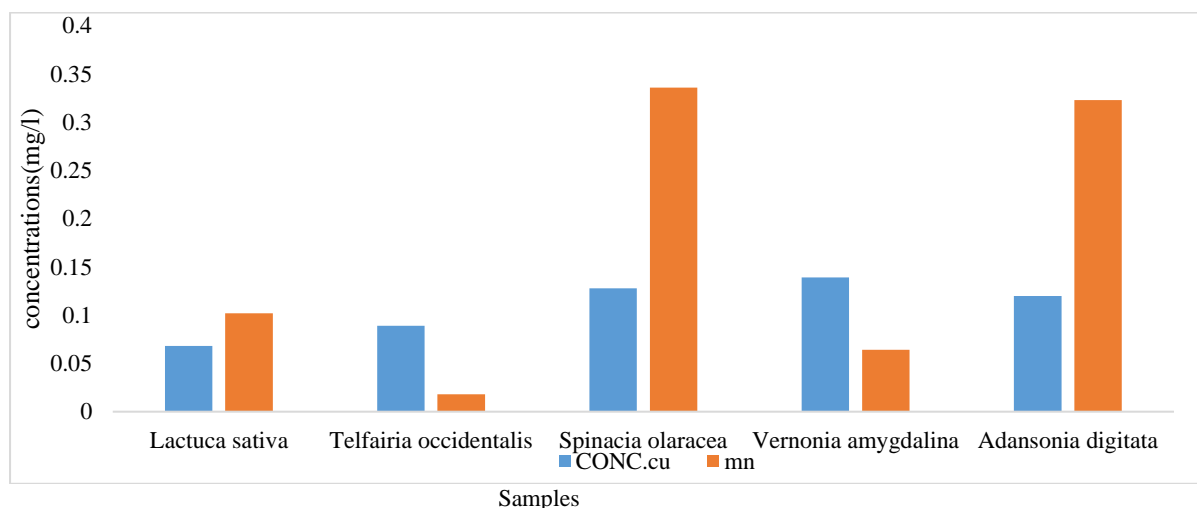


Figure 1: Comparison of mean concentration of Cu and Mn levels in selected vegetables

4.0 DISCUSSION

Vegetables may contain certain amount of heavy metals in high concentrations that can be toxic to the body and long-term consumption of these vegetables increase the possibility of tissue-organ damage. It is known that some heavy metals (Zn, Cu, Mn, etc) are micronutrients at low concentration. Nevertheless, metals are most often found as contaminants in vegetables. These metals pose a significant health risk to humans, especially when they reach high concentrations in the body. This can be expressed in the inhibition or activation of certain enzymatic processes after the productivity from both qualitative and quantitative aspects (Saikat *et al.*, 2020). A lot of people develop kidney damage, cardiac disease, brain disorder and liver problem as a result of consuming vegetables contaminated with a high concentration of heavy metals. These problems arise as a result of the lack of heavy metal assessment of these vegetables. Also, manganese deficiency will cause a number of detrimental effects, such as impaired growth, poor bone formation and skeletal defects, reduced fertility and birth defects, and altered lipid and carbohydrate metabolism in both animals and humans.

The results of this study showed that 100 % of the samples were contaminated with Mn and Cu. The mean \pm SD concentrations of Cu in the samples analysed ranged from 0.068 \pm 0.005 to 0.139 \pm 0.0002 mg/kg, with *Vernonia amygdalina* recording the highest concentration while *Lactuca sativa* having the least (Table 1). The content of Cu recorded in all the vegetable samples are within the WHO limit (4 mg/kg dry weight of plant) for Cu in plant materials.

Similarly, the mean concentration of Mn in the samples analysed also ranged from 0.018 \pm 0.013 to 0.336 \pm 0.001 mg/kg. The highest concentration of Mn was found in *Spinacia oleracea* while the least concentration was recorded in *Telfairia occidentalis* sample. However, all the concentrations from the five vegetables are also within the WHO official limit (5 mg/kg dry weight of plant material). The results suggest that, the five green vegetables are fit for human consumption as their level of Cu and Mn are within the official limit though, levels of other heavy metals were not assessed based on the location where sampling was carried out. The fact that concentrations of Mn and Cu observed

in all the samples did not differ significantly ($P < 0.05$) irrespective of the sampling site.

From the literature, Mohammed and Khairia (2012) detected a concentration ($14.0 \mu\text{g/g}$) of copper in spinach which was above the WHO official permissible limit (10mg/kg). The high level of Cu recorded may be due to the emission of the elements from the industries and vehicles deposited on the vegetable surfaces during their production, transport and marketing.

Tudi *et al.*, 2021 detected the ranged concentrations ($0.06\text{-}0.15 \text{ mg/kg}$) of copper in spinach, and ($0.30\text{-}9.70 \text{ mg/kg}$) of lettuce which all within the official permissible limit (4 mg/kg).

5.0 CONCLUSION

The study revealed that Cu and Mn were detected in all five samples of the and vegetable herbs and the levels in all the samples are within the WHO limit in plant materials.

Therefore, the consumption of the sampled vegetables by the residents of the study area may not be associated with the manifestation of the toxic effects of Cu and Mn.

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